PRESSURE SENSOR

FIELD OF THE INVENTION

The present invention relates to a pressure sensor having a diaphragm which is differently deformable or locally changeable through pressure differences.

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BACKGROUND INFORMATION

A conventional pressure sensor of this type is based on the deflection of a deformable diaphragm being detected for the pressure measurement. A problem is, for example, provide to

10   perform a pressure measurement in the combustion chamber of an internal combustion engine, in which temperatures of more than 500°C exist.

SUMMARY

15   An object of the present invention is to provide a pressure sensor of the above-cited type, by which pressures can be measured reliably even in the event of unfavorable measurement conditions, for example, even in poorly accessible spaces having high temperatures.
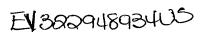
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According to an example embodiment of the present invention, for this purpose, at least one functional section of the diaphragm has a material which has the properties of a black-body radiator or has an emissivity used for detection in the

25   spectral radiation range which corresponds to the temperature of the diaphragm under its conditions of use, and a radiation receiving unit which detects at least a portion of the emitted radiation, having at least one infrared radiation sensor, is assigned to the diaphragm.

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Using this construction, the pressure is recorded and analyzed
on the basis of a temperature detection of the diaphragm. The
measurement is based on Planck's radiation law, according to
which the radiant power per surface unit of a black-body
5   radiator and per wavelength unit is determined by conventional
formulas. In this case, the spectral emissivity of a surface
is defined as the ratio between the spectral radiation density
of this surface and the spectral radiation density of the
black-body radiator at the same temperature. This function is
10   less than or equal to 1 and, if it is constant, the surface is
referred to as a gray radiator.

For illustration, Figure 4 shows the spectral density of the
radiant power for temperatures of 300°C, 400°C, 500°C, and
15   600°C for a radiant surface of 1 mm diameter and an emissivity
= 1 (black-body radiator). The maximum of the spectral radiant
power varies between 5 μm for a temperature of 300°C and 3.3
μm for a temperature of 600°C. The curves display a much
steeper shape on the left to the maximum, i.e., toward shorter
20   wavelengths, than to the right, i.e., toward longer
wavelengths. The radiation sensor and filters possibly
positioned in front of it are selected in accordance with the
existing temperature range.

25   Defined radiation and detection is favored if the functional
section is positioned in a central area of the diaphragm and
is implemented by coating the material, and the functional
section is surrounded by a section which has a lower
emissivity in at least the radiation range corresponding to
30   the temperature of the diaphragm under the conditions of use.

Various example advantageous embodiments include the
functional section being coated with carbon black, iron oxide,

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oxidized copper, or oxidized steel, and/or the surrounding section carrying a gold plating.

A stable, reliably functioning construction may be obtained by
5   positioning an infrared conductor between the radiation receiver unit and the diaphragm, which is transparent in at least the spectral radiation range corresponding to the conditions of use of the pressure sensor. The high transparency in the relevant spectral radiation range may be
10   selected in such a way that there is generally no attenuation of the radiation emitted by the diaphragm.

In this case, advantageous embodiment variations include the infrared conductor having a tubular section having a treated
15   inner wall surface for guiding the infrared radiation emitted by the diaphragm and/or the infrared conductor having a dielectric waveguide for guiding the infrared radiation emitted by the diaphragm, it also being able to be advantageous that the infrared conductor, if it is implemented
20   having a tubular section, carries a smooth surface having a roughness smaller than the relevant wavelengths and a coating reflecting at least the majority of the infrared radiation of the diaphragm, or that the infrared conductor, if it is implemented having a waveguide, is made of germanium,
25   sapphire, quartz, calcium fluoride, or sodium chloride.

For this purpose, the infrared conductor may also have lens elements for radiation guiding.

30   The infrared radiation sensor having its radiation sensitivity tailored to the infrared radiation of the diaphragm and the radiation receiving unit being adapted to the oscillation frequency of the diaphragm contribute to the sensitivity and measurement precision. An analysis unit assigned to the

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radiation receiving unit may also be easily designed in a
suitable manner for the measurement.

Various further possible embodiments result in the infrared
5   radiation receiver having a pyroelectric detector, a
bolometer, or a thermopile.

Furthermore, assigning a cooling device to the infrared
radiation sensor and/or connecting an infrared filter upstream
10   from the infrared radiation sensor for selecting a radiation
band which is relevant to the measurement are advantageous for
obtaining a reliable measured signal.

In order to exclude further negative environmental influences,
15   a further advantageous measure is that the radiation receiver
unit has two infrared radiation sensors, upstream from which
infrared filters of different spectral transparencies are
positioned, and that an analysis unit is implemented in such a
way that the radiation components detected by the two infrared
20   radiation sensors are separated into the component originating
from deflections of the diaphragm and the component
originating from temperature changes of the diaphragm.

BRIEF DESCRIPTION OF THE DRAWINGS
25   The present invention is described in greater detail below on
the basis of exemplary embodiments with reference to the
figures.

Figure 1 shows an illustration of a pressure sensor in a
30   longitudinal section.

Figures 2 and 3 show a change in the radiation flux detected
by a radiation sensor as a function of a deflection of the

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diaphragm of the pressure sensor using a tubular body and/or a
fiber-optic guide.

Figure 4 shows the spectral radiant power of a radiating
5 surface of 1 mm diameter for different temperatures.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS
A pressure sensor shown in Figure 1 has a diaphragm 1, which
is deflectable and/or deformable under the effect of a
10 pressure, and an infrared radiation sensor 4, between which an
infrared conductor 2 is positioned, which guides the infrared
radiation emitted by diaphragm 1 to infrared radiation sensor
4. An optical filter 3 is advantageously positioned upstream
from infrared radiation sensor 4, and a cooling element 5 is
15 assigned to radiation receiver 4. The pressure is measured by
measuring the deflection of diaphragm 1. The deflection is
determined by measuring the change in the radiation flux
detected by infrared radiation sensor 4, as shown by the
diagram shown in Figures 2 and 3.
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A central area of diaphragm 1 is implemented as a functional
section 1.1 and coated with a material which has properties of
a black-body radiator or good emissivity in a spectral
radiation range corresponding to the temperature of diaphragm
25 1 when the pressure sensor is in the state of usage. A
material of this type may be carbon black, iron oxide or a
similar oxide, strongly oxidized copper, oxidized steel, or
the like, for example. A surrounding area 1.2 of central or
inner diaphragm section 1.1 is coated with a material which
30 has only a weak emissivity in the spectral range in which the
pressure sensor is used, so that the radiation source formed
by diaphragm 1 is delimited as clearly as possible. Such a
material may be a thin gold plating, for example.

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Infrared conductor 2 must have good transparency in the spectral range in which the pressure sensor is used. Infrared conductor 2 may be formed via a tubular section and/or a tubular body, whose inner wall surface has a suitable surface

5   state having the lowest possible roughness (smaller than the wavelength) and which is coated with a material which has the best possible reflection in the spectral range corresponding to the use and therefore has the weakest possible emissivity, for which a gold or silver plating or the like is suitable.

10   Infrared conductor 2 having a transparency of this type and inner wall surface 2.1 ensure almost complete transmission of the radiation emitted by the diaphragm to infrared radiation sensor 4.

15   Alternatively to the above-mentioned embodiment or in combination therewith, infrared conductor 2 may also be a dielectric waveguide comparable to a fiber-optic guide, which has good transmissivity in the spectral range corresponding to the use. Materials of this type may be, for example, germanium

20   (for a spectral range from 1.8 μm to 28 μm), sapphire (0.17 μm to 6.5 μm), quartz (0.2 μm to 4.5 μm), calcium fluoride (0.2 μm to 8 μm), sodium chloride (0.2 μm to 26 μm), or the like. The waveguide may also be formed by one or more lenses, which may also be provided in combination with the above-mentioned

25   embodiments.

Infrared radiation sensor 4 is to be as sensitive as possible in the spectral range of the infrared radiation of diaphragm 1 and have a response range which is tailored to the oscillation

30   frequency of diaphragm 1. In addition, cooling element 5, such as a Peltier element, may be provided to cool infrared radiation sensor 4. Radiation sensor 4 may be a pyroelectric detector, a bolometer, a thermopile, or the like. Optical filter 3 is advantageously positioned upstream from infrared

radiation sensor 4 in order to select a precisely tailored
spectral radiation range for the analysis.

In order to differentiate between possible variations of the

5   radiation flux because of a deflection of diaphragm 1 from
those which are to be attributed to a temperature change of
diaphragm 1, at least two infrared radiation receivers 4 may
be positioned one after another, for example, upstream from
each of which an optical filter 3 is positioned, which

10   transmit different spectral radiation ranges, one of the
filters transmitting the radiation component corresponding to
the left part of the curve shown in Figure 4, for example,
where it is steepest, while the other filter transmits the
radiation component corresponding to the right part of the

15   curve, where the slope is significantly flatter, so that a
small temperature change of diaphragm 1 is expressed in
different changes of the component of the radiation flux
incident on the infrared radiation sensor, while a
displacement of diaphragm 1 is expressed in an identical

20   change in the radiation flux at both radiation sensors 4.

Figure 2 shows the change in the radiation flux which is
recorded by functioning infrared radiation sensor 4 in the
event of a deflection of diaphragm 1 in the case in which

25   functional section 1.1 of diaphragm 1 (black-body radiator)
has a diameter of 1 mm at a temperature of 300°C and infrared
conductor 2 is a tubular body of 1 mm diameter, whose entry
surface is positioned 110 μm distance from the surface of
diaphragm 1 when the pressure sensor is in the rest state, it

30   being assumed that the tubular guide body does not cause any
radiation attenuation. Figure 3 shows the change in the
radiation flux under identical conditions, a fiber-optic guide
of 1 mm diameter and a numerical aperture of 0.75 being used
as infrared conductor 2, however. The figures show that

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received radiant power I significantly changes with distance d of the measurement diaphragm, i.e., is reduced with increasing distance.

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